Effectiveness of large livestock protection collars against depredating coyotes

Richard J. Burns, Doris E. Zemlicka, and Peter J. Savarie

Abstract We investigated effectiveness of large livestock protection collars (LLPC's) to kill coyotes (*Canis latrans*) that attacked sheep. The LLPC, designed for sheep and goats >22.7 kg, contained the same formulation of Compound 1080 as the smaller collar (LPC) registered by the Environmental Protection Agency in 1985. In 32 tests involving 19 sheep wearing LLPC's, 12 coyotes made 14 neck or throat attacks. In 10 of the 14 attacks (71%), LLPC's were punctured and all 10 coyotes died. Coyotes that punctured collars showed signs of intoxication in an average of 203 minutes and died an average of 93 minutes later. Time to death did not differ among coyotes that punctured 1 collar compartment versus 2 compartments. The LLPC was more effective in deterring coyote predation on large sheep than the previously registered small LPC.

Key words *Canis latrans*, Compound 1080, coyotes, livestock protection collars, sheep, toxicant

Livestock protection collars (LPC's) are used primarily on sheep and goats in pastures to help reduce coyote (*Canis latrans*) predation. Most authors agree that LPC's have 2 major advantages over other coyote depredation control devices: (1) they selectively remove problem individuals—rarely affecting nontarget animals (Connolly 1980, 1993; Littauer 1984; Walton 1991; Burns and Connolly 1996) and (2) they frequently take coyotes that have avoided other control devices (Connolly 1980, Walton 1990).

The LPC containing Compound 1080 (sodium fluoroacetate) was approved by the U.S. Environmental Protection Agency (EPA; Registration No. 56228-22) in 1985 (Moore 1985) to control coyote depredation on sheep and goats. The approved black-rubber collar is 5.1 x 15.2 cm and holds 30 ml of 1% solution in two 15-ml compartments.

This collar is most effective on lambs and kid goats weighing 11.4-22.7 kg (25-50 pounds; Connolly and Burns 1990). The collar is less effective on larger sheep and goats (Burns et al. 1988, Walton 1990), apparently because it does not adequately cover the neck and throat, sites typically bitten by attacking coyotes. Field tests on 6 ranches in Idaho and Montana showed only 53% (18 of 34) of small collars were bitten by coyotes in attacks on collared lambs that weighed about 31.8 kg (70 pounds) each (G.E. Connolly, Prog. Rep. EPA, Exp. Use Permit 6704-EUP-14, Denver Wildl. Research Center, Colo., 1978). A larger collar (5.6 x 23.5 cm) that held 60 ml of 1.0% 1080 solution in two 30-ml compartments was effective (Burns et al. 1988), but registration was not pursued because of the large amount of toxicant required. We tested the large collar, using the same amount and concentration of toxicant (30 ml of 1.0% 1080) as in the small collar, in killing coyotes that attacked large lambs.

Methods

The study was conducted December 1991-March 1992 at the Denver Wildlife Research Center (DWRC), Predator Research Site in Millville, Utah. The large livestock protection collars (LLPC's) were procured from Rancher's Supply in Alpine, Texas. Compound 1080 was obtained from Tull Chemical

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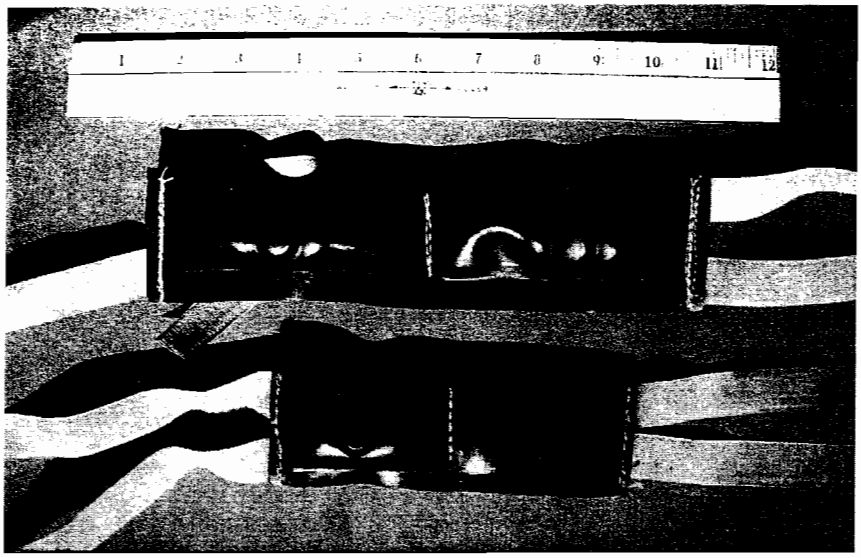

Small livestock protection collar (LPC) and large livestock protection collar (LLPC) compared.

Co., Inc. in Oxford, Alabama. The 1080 was analyzed by DWRC chemists, and results of the analysis were used to calculate the quantity required in the test formulation.

The solution used to fill LLPC's was formulated by adding 5.26 g of Compound 1080 and 2.69 g of tartrazine (93% active ingredient) to 500 ml of deionized water. Tartrazine (Ingredient Tech. Corp., Des Planes, Ill.), a yellow dye, was added to the otherwise colorless solution to indicate 1080 contamination from LLPC's (Burns and Savarie 1989).

Fifteen LLPC's were warmed in an oven to about 60°C, and each of the 2 collar compartments was filled with 15 ml of solution using a hypodermic syringe with a 25-gauge needle. Warming the collars helped ensure proper sealing of punctures to prevent toxicant loss. Each LLPC was filled, numbered, wrapped in enough paper towel to absorb its entire contents if accidentally broken, placed in an identically numbered plastic bag, and weighed on an electronic balance. After a collar was punctured by a coyote, it was returned to the unaltered bag. We used the difference in weight of the entire package before and after the puncture to determine the amount of collar solution lost.

To determine stability of the test formulation, we collected samples before and after the study of stock solution and of solution extracted from a designated LLPC not used in predation tests. We refrigerated all samples before analysis, except those extracted from the designated collar at the end of the study. All LLPC's were stored at room temperature before and after testing.

We used adult coyotes, ≥1 year old, and large lambs, >22.7 kg (healthy, captive-bred animals of both species.) Veterinary care for animals was available but not required during the study. Coyotes were fed about 600 g/day of commercial mink feed and had water *ad libitum*. Sheep were fed alfalfa hay daily and also had water *ad libitum*.

We offered kid goats or lambs to several coyotes to examine their proficiency at killing. We then selected those that were proficient at making throat kills on lambs for the study. Coyotes were acclimated to their test pens, either 250 m^2 or 9,750 m^2 in size, and were fed about 500–600 g of sheep flesh daily for 7 days prior to testing. In each test, we introduced a sheep wearing an LLPC into a pen containing a coyote that had been deprived of food for 0–2 days, and allowed the coyote to attack. We ran the tests for up to 4 hours or until a sheep was attacked. We observed the attacks from a building overlooking the pens and recorded the results on standard forms. If sheep were not attacked, they were used in subsequent tests or returned to the flock after we removed their undamaged collars. Coyotes that did not attack were either tested again with the same or a different sheep or were removed from the study. If sheep were attacked and wounded but not killed, we euthanatized them as quickly as possible.

After a test in which 1 or both LLPC compartments were punctured by a coyote and the sheep was killed or euthanatized, coyotes were captured and moved to isolated kennels to prevent potential contamination of test pens or exposure of other coyotes to emesis containing 1080. Coyotes were monitored and indications of toxic reaction (Burns et al. 1991) were recorded at about 30-minute intervals for 6 hours from the time coyotes entered isolated kennels. For the next 18 hours, observations were recorded at about 6-hour intervals. When signs of intoxication were seen, continuous observation was begun to determine time of death. Body weights were recorded for sheep before testing and for coyotes after death.

Animal carcasses and all pen contamination, as identified by yellow dye, were collected and dis-

posed of by deep burial according to EPA recommendations. Coyotes and sheep free of contamination remained at the research facility. Animal holding facilities were routinely inspected by a Regulatory Enforcement and Animal Care (REAC) veterinarian, who enforces compliance with the Animal Welfare Act. All animal study and maintenance procedures were reviewed by the Institutional Animal Care and Use Committee (IACUC) of the Denver Wildlife Research Center.

Results

Compound 1080 used in the study assayed at 95.1% active ingredient (n = 5, SD = 0.7, Coefficient of Variation [CV] = 0.8%). Samples of solution from the designated LLPC on the day it was filled and at the end of the study had mean concentrations of 10.1 mg/ml (n = 3, SD = 0.12, CV = 1.2%) and 10.4 mg/ml (n = 3, SD = 0.06, CV = 0.6%), respectively. These results indicated that the intended concentration was tested in LLPC's and that the LLPC solution was stable during testing.

We conducted 32 pen tests involving 19 sheep wearing LLPC's. Twelve coyotes (6 males, 6 females) with mean weights of 10.8 kg (range = 8.9-12.2 kg) made 14 attacks directed at throats of collared sheep; LLPC's were punctured in 10 (71%) attacks. All 10 (100%) coyotes that punctured collars died. Of the 10 collars punctured, 5 occurred on the first, 3 on the second, and 1 each on the third and seventh attacks on sheep by any single coyote (Table 1). The 14 sheep killed by coyotes or euthanatized after an attack each weighed >22.7 kg (mean = 29.2 kg, range = 26.2-34.8 kg). The 10 sheep wearing LLPC's punctured by coyotes had a mean weight of 29.8 kg (range = 26.2-34.8 kg). We saw no indication that LLPC's on lambs influenced coyote attacks in any way.

Coyotes that died had an estimated mean latent period (free from signs of intoxication) from the estimated time of collar puncture to the onset of intoxication of 203 minutes (n = 10, range = 117-323 minutes). Mean time to death after the onset of intoxication signs was 93 minutes (n = 10, range = 12-265 minutes). Mean total time from estimated collar puncture to death was 295 minutes (n = 10, range = 156-548 minutes). Mean total time to death was 342 minutes (n = 6, range = 182-548 minutes) for coyotes puncturing 1 LLPC compartment and 225 minutes (n = 4, range = 156-360 minutes) for those puncturing 2. Although mean time to death appeared shorter for coyotes puncturing both collar compartments, the times did not differ (z = -1.358, P = 0.17).

When coyotes punctured LLPC compartments, nearly all contents drained. Weight loss from LLPC's with 1 compartment punctured indicated an average solution loss of 14.1 ml (n = 6, range = 13.3-15.0 ml) and 24.3 ml (n = 4, range = 21.3-28.9 ml) from LLPC's with 2 compartments punctured. Total loss of Compound 1080 during the study was calculated at 1.82 g (14.1 ml x 6 + 24.3 ml x 4 = 181.8 ml x 10 mg/ml = 1,818 mg = 1.82 g). These loss measurements were slightly low because most collars had small amounts of debris adhering to them during post-test weighing. However, based on a maximum possible loss of 15 ml/compartment punctured, only 2.1 g (15 ml x 14 = 210 ml x 10 mg/ml = 2,100 mg = 2.1 g) of 1080 could have been lost.

Large livestock protection collar (LLPC) on sheep.

Discussion

We found through post-test analysis that the concentration of 1080 in LLPC's did not decrease over the 4-month course of study. Stability analyses at the DWRC indicated a 7-8% increase in the concentration of 1080 in small collars during 1 year of storage (R. W. Timm, Denver Wildl. Res. Center, pers. commun., 1994). This increase could have

Table 1. Coyote identification numbers, sex, weight, number of times tested, and results of captive coyote attacks on lambs wearing large livestock protection collars (LLPC) in Utah, 1991–1992.

Coyotes tested			No. of tests	Throat kill without collar puncture	Throat attack with collar puncture	Fate of coyote
No.	Sex	Weight (kg)				
D685	F	9.8	2	0	1	died
D687	F	11.2	3	0	0	survived[a]
D688	M	12.2	1	0	1	died
3157	M	11.3	2	0	1	died
3187	F	—[b]	1	0	1	died
3423	M	11.5	1	0	1	died
3425	M	10.5	1	0	1	died
3447	F	12.0	8	2	0	survived[a]
5035	M	10.5	2	1	1	died
5039	F	13.3	7	1	1	died
5101	M	8.9	3	0	1	died
5117	F	9.7	1	0	1	died
Totals	12		32	4	10	

[a] Coyotes that survived did not puncture LLPC's.
[b] Coyote not weighed.

resulted from gradual water loss through the rubber collar walls. Evidently, the 1080 formulation is quite stable in collars.

In prior tests of large livestock collars containing 60 ml of 1.0% 1080 solution, all coyotes that punctured collars died in an average of 154 minutes (Burns et al. 1988). The number of deaths/collar punctured was the same as reported here, but mean time to death was shorter (154 vs. 295 minutes); the difference was expected, however, because collars in the earlier study contained twice the volume of toxic solution.

Most of the coyotes attacked collared lambs repeatedly during tests until they punctured a collar and were killed by the toxicant. This corroborates earlier findings that coyotes are not repelled by and do not learn aversion to LPC's or collared sheep (Connolly and Burns 1990). Coyotes that puncture collars on sheep are not deterred even when the collars contain repellent or aversive agents (Burns et al. 1984).

Effectiveness of LPC's containing 1080 in protecting livestock depends on several factors including whether: (1) coyotes attack collared livestock, (2) collars are punctured in the attack, and (3) stock-killing coyotes are removed during attacks (Connolly and Burns 1990). Important factors directly related to efficacy of the collar are the number of collars punctured and the number of coyotes killed during throat attacks on collared livestock. Under field conditions, most coyotes that puncture collars are not found, but experience with captive coyotes indicates that coyotes puncturing collars do not survive (Connolly and Burns 1990).

In previous studies, the efficacy of collar punctures by coyotes during throat attacks varied with collar material and size and with size and species of livestock. The small LPC, which is registered for use by the EPA, was effective 46% of the time in field tests and 72% in pen tests with sheep (Connolly and Burns 1990), 83% in field tests on Angora goats in Texas (Wade and Connolly 1980) and 50% in a field test on sheep in New Mexico (Littauer 1984). The mean for these 4 studies was 63%, or 56% for the 3 involving sheep. Both means are well below the 71% that we found in this study, but results in both pen tests were similar (71% vs. 72%).

The small LPC has had a negligible effect on nontarget species in research and operational use (Connolly 1980, 1993; Littauer 1984; Walton 1991; Burns and Connolly 1996). No increase in negative environmental impacts is expected with the LLPC because the formulation evaluated in LLPC's was the same as that used in small LPC's. The LLPC should be more efficient than the LPC in reducing coyote predation on sheep and goats weighing >22.7 kg.

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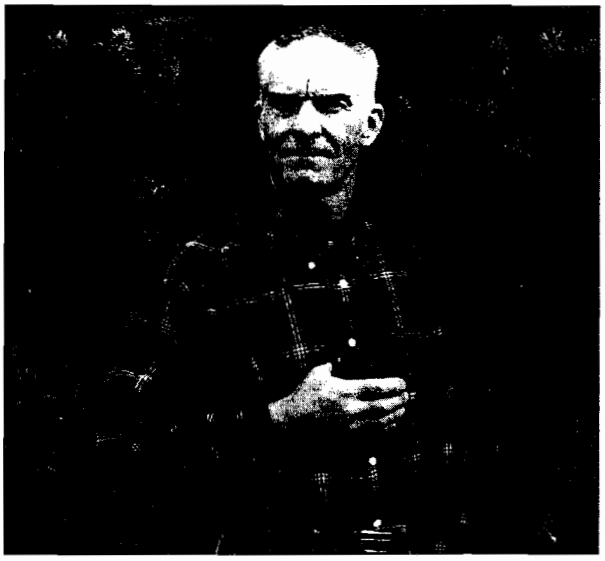

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